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Title: LANL Binder-Jet and DLP Options for Ceramics and Porous Metals

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LANL Binder-Jet and DLP Options for Ceramics and Porous Metals

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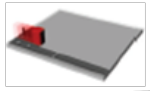
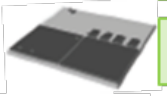
NNSA National Nuclear Security Administration
Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

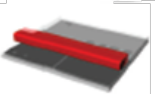
Binder-Jet AM Technology



1. Spread Powder & Print
Powdered material is spread. Binder is selectively dispensed using inkjet printing technology.



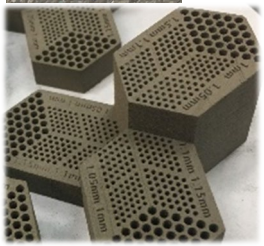
2. Recoat
The build platform is lowered by a set increment



3. Spread
A new layer of powdered material is spread

4. Repeat
Steps 1-3 are repeated until the part is built.

5. Finish
Unbound metal is removed. Parts are cured, sintered or sintered and infiltrated

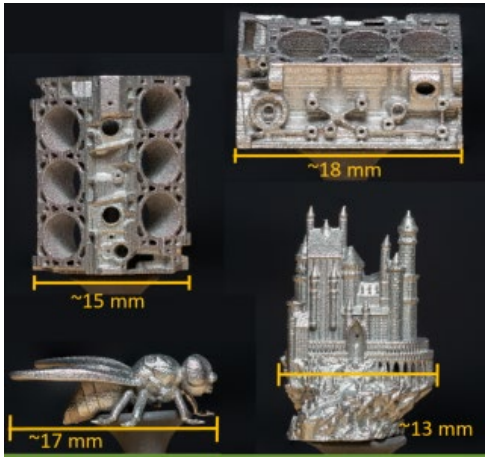


With 30 µm mono-sized spherical powder
Prints 65% dense (green) 35% Air or infiltrate

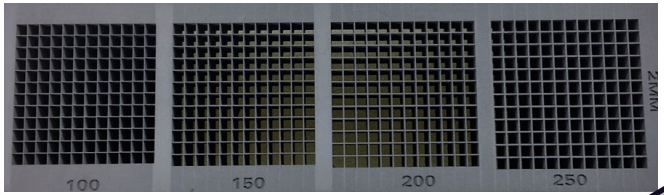
- Shrinkage Scaling Factors of 0.5-1.5% Applied Isotropically
- Typical deviation of .002 in/in for small parts and .007 in/in; .003 in/in up to 3.5 in;
- **No support material required = complex parts**
- Infiltration with bronze/other metals for high density

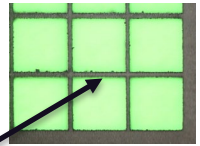
9 micron powder
50 micron layers

Measured Densities
316L: 0.985 - 0.989
17-4 PH: 0.974-0.987



- Surface finish of 8µm Ra
- Wall thickness < 0.5 mm
- Resolution of 100 µm or less
- Min layer thickness 30µm (25µm after curing)



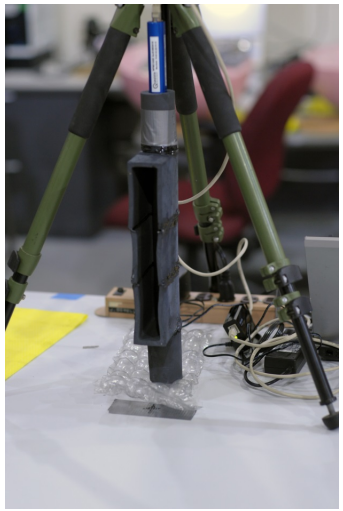


Images of the cured state 100 µm width grid lines (courtesy of ExOne)

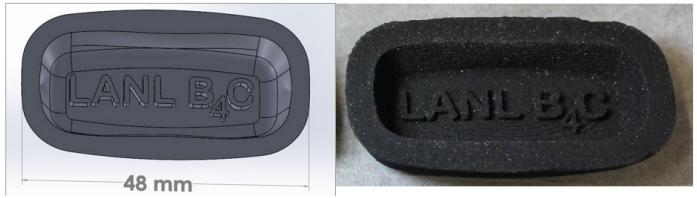
Have Printed Some B_4C and Tungsten Parts

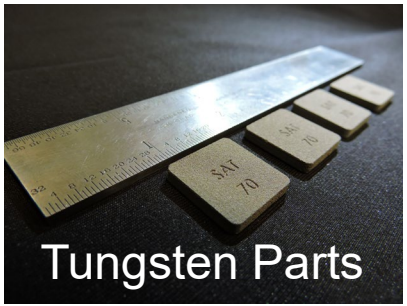
Larry Bronisz (E-1), James M Thompson (E-1),
Chris Chen (Sigma), Johnathan Dowel (retired)

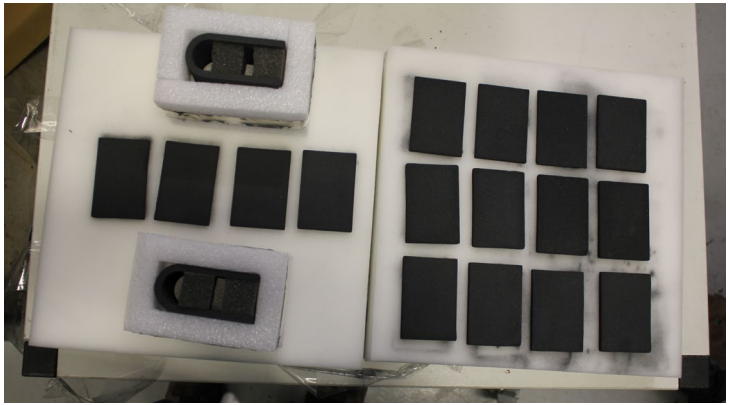
- B_4C Thermal Neutron Shielding for Lighthouse Detector Project
- Developed and tested parameters
- Pure mono-sized 30um powder cured for 9hrs at 212 °C



- Achieved green densities 45%
- Complex Contours Printed
- Achieved sintered densities
- Good Feature resolution
- ORNL Aluminum infiltration can be done

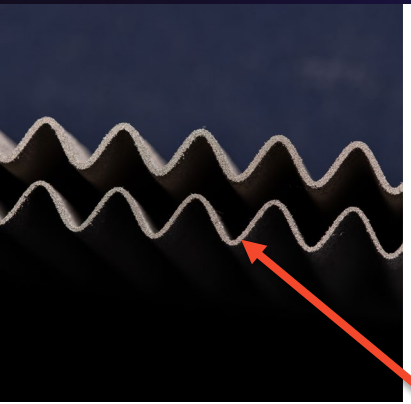


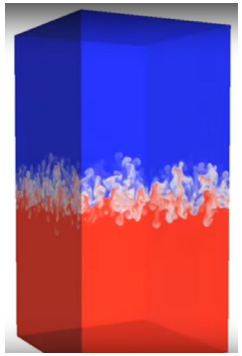




Thin Shockwave Membranes

Larry Bronisz (E-1), James M Thompson (E-1), John Charonko (P-23), Tiffany Desjardins (P-23)



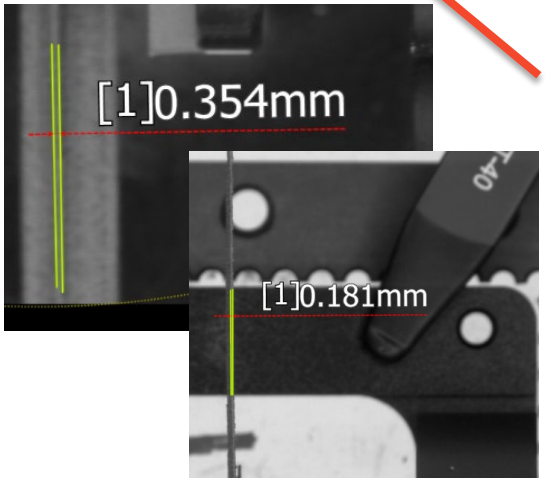


Membranes initiate sinusoidal shock front in disparate gases in vertical shock tube apparatus. (P-23)

Shock input “smithereens” membrane so gas turbulence can be studied.

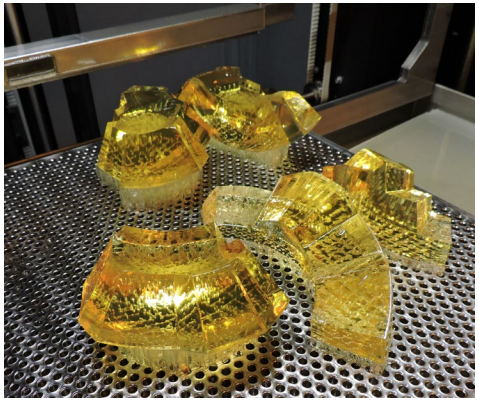
- Planer Laser Induced Fluorescence (PLIF)
- Particle Image Velocimetry (PIV)

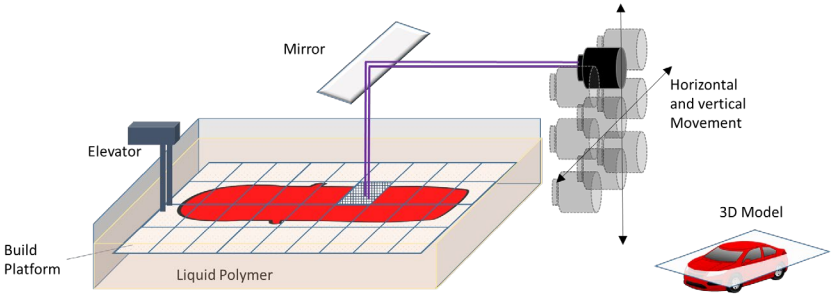
Rayleigh-Taylor Instability

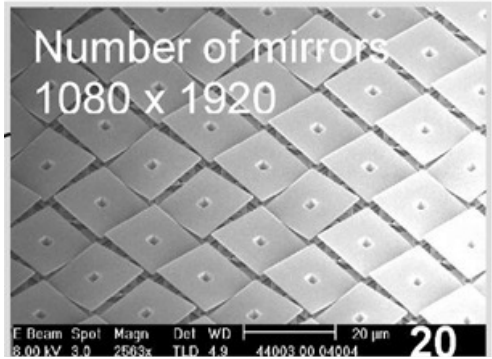


Exquisitely Thin Membranes

Moving Light DLP

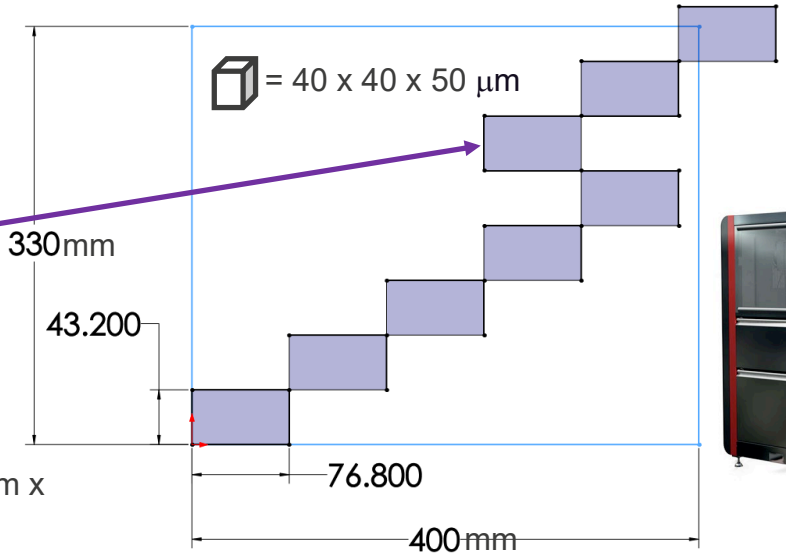






DLP (Digital Light Processing) uses micro-mirror array to Project cross section onto resin bottom-up or top-down;

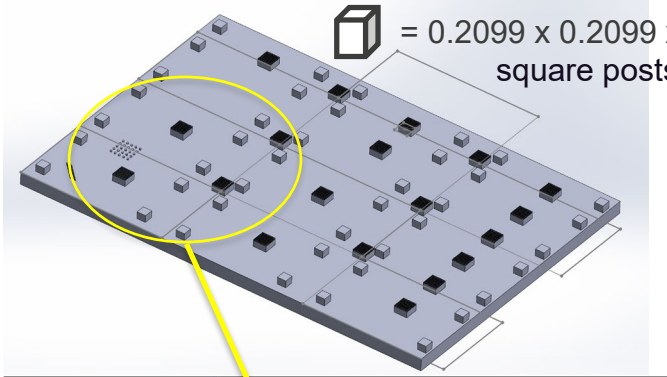
- faster, yet less intense than laser
- Accuracy better than 20μm within a **tile**
- Large part accuracy < 0.2% (< 2 parts per 1000)



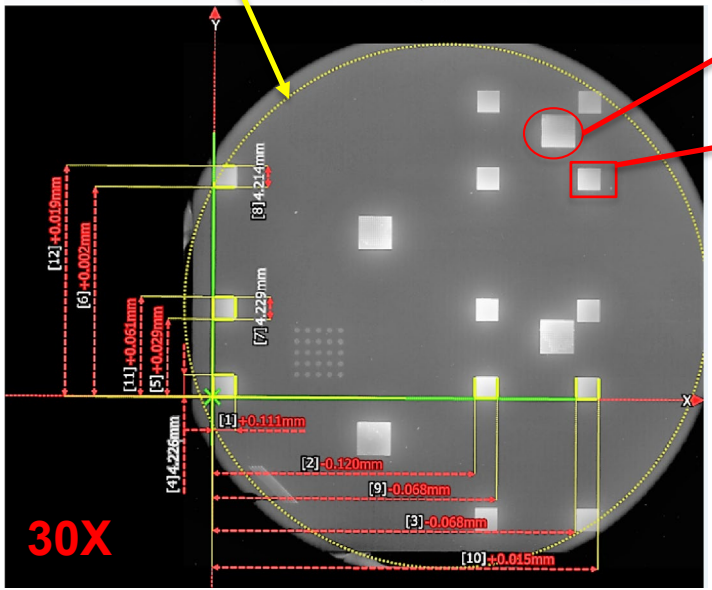
Prodways Promaker L5000 (developed for Dental Industry)

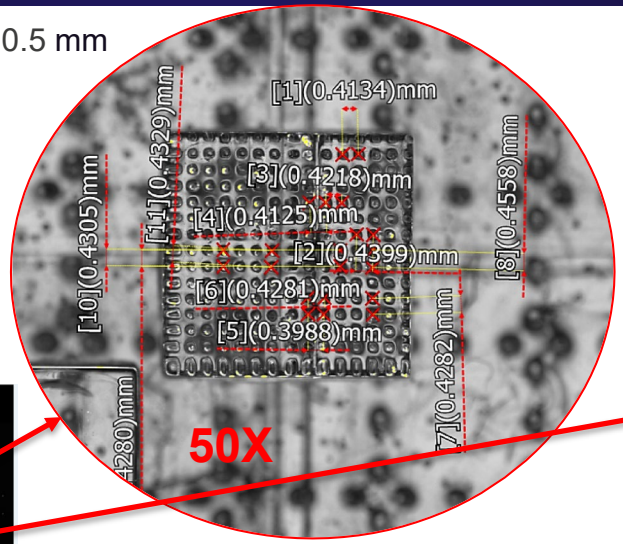
- Open material platform
- Machine is a tiling, top-down DLP system
- Provides 40μm resolution for larger parts 400mm x 300mm x 400mm tall – Finest large format polymer printer at LANL

KEYENCE Optical Metrology Measurements

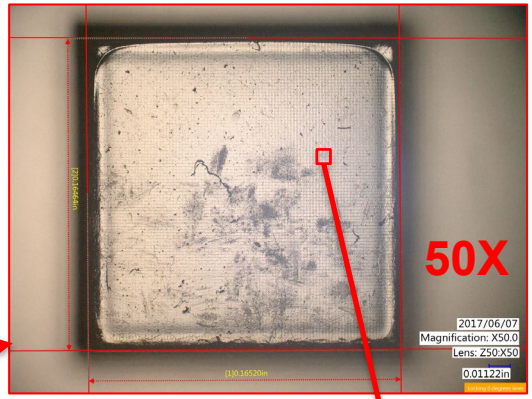


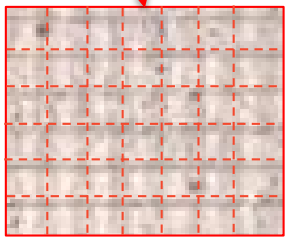
= 0.2099 x 0.2099 x 0.5 mm square posts





Photos by Matt Velasquez





40μm Pixels

Keyence calibrated optical metrology:

- Y Direction (post spacing pitch)

CAD: 0.4197mm

Measured: 0.4305, 0.4282, 0.4329, 0.4280, 0.4558

Average: 0.4351

Average Deviation: 0.0154 or 15.4 μm

- X Direction (post spacing pitch)

CAD: 0.4197

Measured: 0.4134, 0.4218, 0.4399, 0.4281, 0.4125

Average: 0.4231

Average Deviation: 0.0034 or 3.4 μm

Materials Possible with Binder-Jet and DLP

Binder-Jet AM

- Carbon and Graphite materials
- 40-50% green porosity
- Ceramic carbon composite
- Porosity < 0.1% vol (when infiltrated with silicon carbide)
- (Explored by ExOne in collaboration with SGL Group)
- Densities achievable with 9 µm powder expected to be high

Moving Light DLP

- Success with printing ceramics in clear resins at high resolution (feature size 360 µm)
- Tested loading percentage 20 wt%
- Very high silicate loading densities have been achieved by *Perfect 3D*
- Perfect 3D collaborates with USAF and LLNL

Cores

Molds

Filters

PRODWAYS
THE NEW WAY OF PRODUCING

PERFECT 3D